Hybrid System for Post-Combustion NO_x Reduction SNCR and Air Heater SCR

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The Clean Air Act Amendments of 1990 have given rise to a wave of technology developments aimed at meeting clean air requirements. Indeed, in the first half of this decade, the U.S. witnessed the retrofit of low NO_x burners on coal, oil, and gas-fired boilers. Additionally, there were new developments in air staging technologies, gas reburn demonstrations under the Clean Coal Technology Program, in-field applications of SNCR retrofit on various types of utility boilers, and even retrofit applications of SCR. In preparation for "life beyond Phase I", efforts are now being focused on field development of effective combinations of NO_x control technologies. Potentially, two or more available means of NO_x control can be compatibly combined to reduce NO_x .

Hybrid SNCR/SCR is a combination of a redesigned SNCR and downstream SCR, optimized to provide improvements in chemical utilization and overall NO_x reduction. The two NO_x reduction technologies each provide process strengths which make the hybrid combination more flexible and effective than the sum of its parts.

Selective Non-Catalytic Reduction (SNCR) is typically performed in the furnace, where relatively high temperatures serve to initiate the breakdown of urea or ammonia to form the transient species which lead to effective NO_x reduction. The technology is limited to high temperature zones which insure very low ammonia slip levels. At very high furnace temperatures, however, performance can be lessened by competing reactions which either consume effective chemical or lead to NO_x formation. Therefore, the perceived limitations of SNCR technology (limited reduction efficiency and chemical utilization) are not inherent for this technology. They are the direct consequences of the requirement to minimize ammonia slip and balance of plant impacts. Should this restriction be eliminated (by arranging for a downstream "ammonia sink"), SNCR system may be modified to inject a chemical in cooler regions where NO_x reduction and chemical utilization improve dramatically.

The logical candidate for ammonia mopping is Selective Catalytic Reduction (SCR) which is typically performed in much cooler flue gas passes where the oxidation potential of nitrogen species is minimized. The catalytic surface provides sites which permit the ammonia and NO_x to react at nearly perfect utilization. The requirements for this SCR component of the hybrid system differ significantly from those of the stand-alone SCR, such as:

- ammonia utilization should be as high as 60% - 80%
- required SCR NO_x reduction may be as low as 10% - 30%
- small volume of catalyst fitting into available space.

For example, a hybrid system which achieves 65% overall NO_x reduction (50% reduction with SNCR and an additional 30% SCR reduction) requires less than one-third the catalyst required for 65% SCR reduction. The smaller catalyst volume converts proportionally less SO_2 to SO_3 in the flue gas, and decreases the pressure drop by the same fraction. When catalyst size is minimized, it may fit into the existing or expanded flue gas duct.

An attractive solution is to place catalyst on the heating elements in the hot layer of the regenerative air preheater, where all the conditions are favorable for the V/Ti catalyst:

- proper temperature range (550°F - 750°F)
- expanded surface area
- efficient mass transfer.

This patented approach is not only the least intrusive one, but also does not require any additional fan capacity (concern over pressure drop). In this case, the air heater works not only as a heat exchanger, but also as a chemical reactor reducing NO_x and reducing the ammonia slip from the SNCR process.

Both mathematical and physical modeling techniques were employed to develop predictive capabilities for SNCR and SCR stages. The SNCR models (including CFD and chemical kinetics) were refined in over 200 installation.

Over 60 different heating elements (catalyzed and non-catalyzed) were tested within the specially developed experimental facility. This database enables the precise prediction of thermal performance and NO_x reduction in regenerative air heaters.

These models were used to modify the sub-systems for achieving the optimal performance of the hybrid system. In many cases, SNCR performance, as well as reagent utilization, is significantly increased by eliminating the restrictions imposed by ammonia slip. The results of modeling are verified by full scale demonstrations undertaken by Wahlco and Nalco Fuel Tech on coal, oil, and gas fired utility boilers at SDG&E's Encina Power Plant and PSE&G's Mercer Generating Station. The test data supports the attractiveness, integrity, and benefits of the hybrid concept.

The key to minimizing lifecycle NO_x reduction costs is to find the appropriate balance between annualized capital charges and operating costs for the remaining life of the unit. The challenge for an SCR retrofit is to minimize the capital requirements. The challenge for SNCR is minimization of reagent required. Designing hybrid SNCR/SCR system suggests that optimization of these costs can be realized for a specific level of NO_x reduction. The synergy between the stages results in a favorable economic evaluation. NO_x reduction levels previously offered only by reactor housed SCR can now be achieved with a hybrid SNCR/SCR system at a fraction of the cost.

The benefits that the hybrid SNCR/SCR system brings to end users include:

- Ability to provide staged performance and staged costs.
- High efficiency performance while balancing capital and operating costs.
- Minor impact on plant operations (NH_3 slip, pressure drop).
- Non-intrusive, easily retrofitted, expandable.
- A more flexible NO_x reduction system.